QUICK REACTION ANALYSIS REPORT

HQ TRAC-RPD-QRAR-1-90

MUNITIONS REQUIREMENTS DECISION SUPPORT SYSTEM (MRDSS)

MAY 1990

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The Munitions Requirements Decision Support System (MRDSS) is a macro-level Decision Support System (DSS) designed to assist the user in determining the optimum munitions requirements for various types of munitions. The MRDSS uses a threat based technology at a macro-level of detail to support a quick-turnaround, sensitivity analyses of munitions requirements. It uses an electronic spreadsheet (Lotus 1-2-3) which allows the user to quickly change certain assumptions and constraints and observe the impact of munitions requirements. The DSS considers specific user-defined direct fire and indirect fire munitions against tanks, BMPs, BRDMs and other threats. The user must specify and allocate threat quantities, allocate required kills to area of operations, and allocate required kills to the specified munitions. The MRDSS then calculates required kills by munition type, rounds required per kill and total rounds required. Additionally, the MRDSS

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enables the user to adjust these estimates for real world wartime inefficiencies such as combat losses, contingency of supplies, tactics, sustainment operations and other inefficiencies.

ACKNOWLEDGMENTS

HQ TRADOC, DCSCD requested that HQ TRAC, Requirements and Programs Directorate (RPD) develop a decision support system (DSS) to assist TRADOC planners with staff actions/studies on the Army's munitions requirements. The DSS which RPD developed was approved by the ADCSCD for his staff use during Long-Range Research, Development and Acquisition Plan (LRRDAP) deliberations and by the Commander, Combined Arms Center, for use in a follow-on staff study conducted by that organization. This report documents the DSS.

The methodology presented in this report was developed by HQ TRAC, RPD. Support to the development effort was provided by HQ TRADOC's Plans, Concepts and Technology Directorate under the Deputy Chief of Staff for Combat Developments and the Threat Directorate under the Deputy Chief of Staff for Intelligence.

The HQ TRAC, RPD analysts were LTC Robert M. Baker, Mr. Robert L. Ford, CPT(P) William N. Prokopyk and Mr. Barry R. Wise.

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WARNING

Information and data contained herein are based on inputs available at the time of presentation. The results are subject to change.

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MUNITIONS REQUIREMENTS DECISION SUPPORT SYSTEM (MRDSS)

1.0 BACKGROUND

The Munitions Requirements Decision Support System (MRDSS) is a macro-level decision support system (DSS) developed to assist the TRADOC DCSCD during Long-Range Research, Development and Acquisition Plan (LRRDAP) deliberations. The tasking from DCSCD was to produce a threat based methodology at a macro-level of detail that would support quick-turnaround, sensitivity analyses of anti-tank and air defense munition requirements. The Quick Reaction Analysis Team from the TRADOC Analysis Command's Requirements and Programs Directorate was given two weeks to accomplish this task.

2.0 GOAL

The goal was to keep the methodology simple, visible and responsive to changes in major factors affecting munitions requirements. It was acknowledged and accepted by all concerned that to accomplish this goal, some input data would be highly aggregated and subjective.

3.0 APPROACH

The approach used was to develop an electronic spreadsheet (LOTUS 1-2-3) which would allow the DCSCD staff to quickly change certain assumptions and constraints and observe the impact on munition requirements.

4.0 METHODOLOGY OVERVIEW

An overview of the methodology is shown in Figure 4.1. The specifics will be presented in the section on the application of the methodology. The first input is a list of the munitions to be included in the analysis. Given a specified munition set, the next step is to enter the quantity and type of threat weapon systems that are to be included as targets for this set of munitions. Once these quantities are identified, it is necessary to estimate the percentage of each target set that needs to be killed in order to accomplish the decisionmaker's objective. This is called the "attack criteria" and is the first of three sets of input factors which require the attention of the decisionmaker and/or subject matter experts. The attack criteria for each target type is multiplied times the threat quantity for that target type and the product defined as the "required kills" for each target type. The "required kills" are then allocated across the munition set. This is a two-step process that requires the use of the second set of subjective factors. First, the "required kills" are allocated to groups of munition. For example, for anti-tank munitions the first allocation might be 70% to direct fire systems, 20% to indirect fire systems and the remaining 10% to the air force. Once this is done, it is necessary to allocate within each of the groups, specific munition types. The next step is to calculate the number of rounds of each type of munition which must be fired against each type of target to achieve a single kill. Since this number is a random variable, probability theory is used to provide an appropriate point estimate of its value. Having estimated the required number of kills and the rounds required per kill, simple multiplication yields an estimate of the total number of rounds required. This estimate is referred to as the maximum efficiency estimator as it represents the number of munitions required under ideal circumstances, e.g., all the munitions are available at the right place, at the right time, there is no fratricide, overkills, etc.. Since this perfect environment does not exist on the battlefield, it is necessary to increase the maximum efficiency estimator to account for a number of inefficiencies. This requires the use of the third and final set of subjective factors. This third set of factors represent the percent that the maximum efficiency estimators must be increased to account for specific inefficiencies in the environment. This produces the final estimate of the munition requirements and the last output of the DSS. The final step of the methodology is accomplished "off-line" and involves a graphic comparison of the DSS estimates and the programmed inventories for each munition.

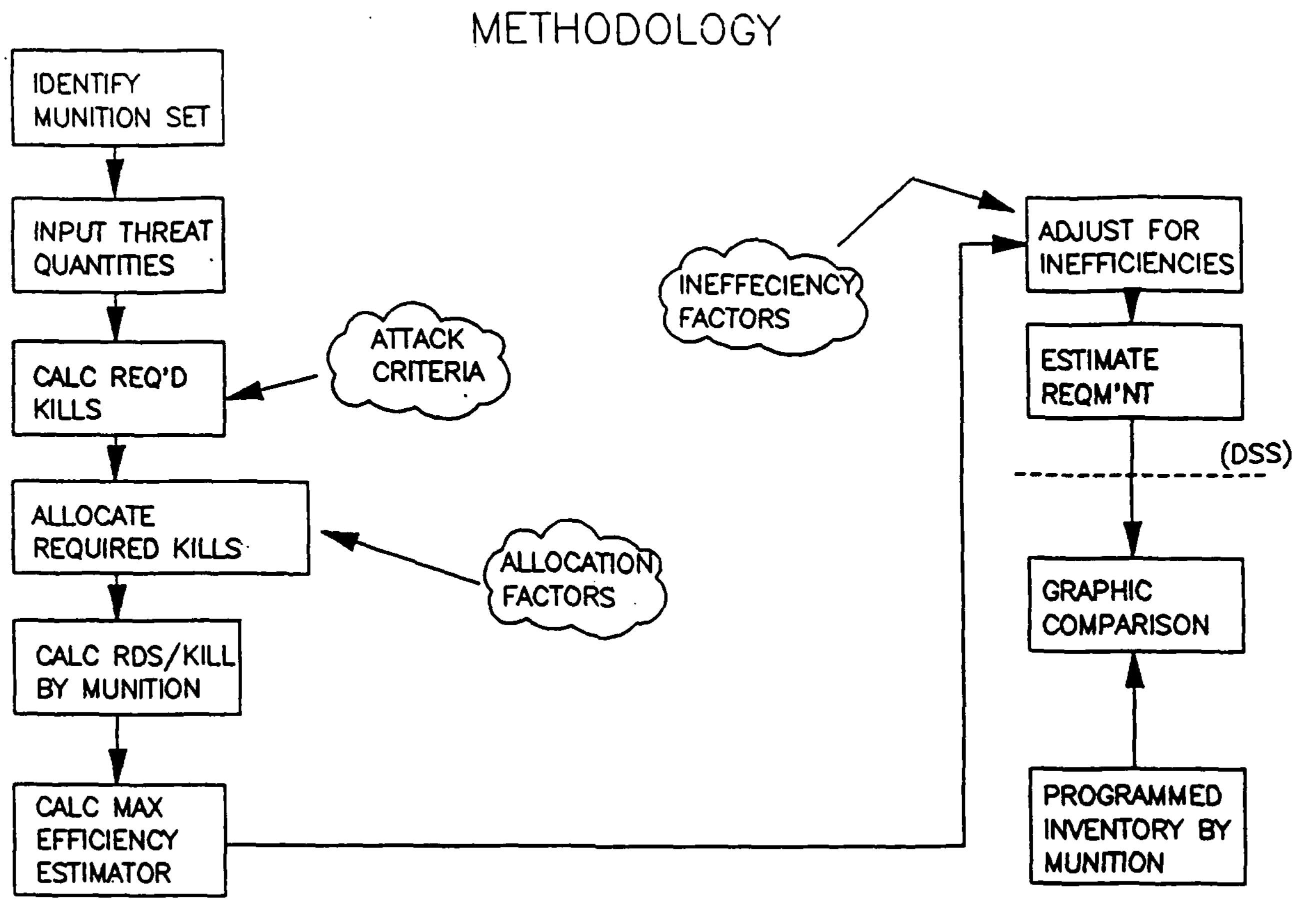
METHODOLOGY
IDENTIFY MUNITION SET
INPUT THREAT QUANTITIES
CALC REQ'D KILLS
ATTACK CRITERIA
ALLOCATE REQUIRED KILLS
ALLOCATION FACTORS
CALC RDS/KILL BY MUNITION
CALC MAX EFFICIENCY ESTIMATOR
INEFFECIENCY FACTORS
ADJUST FOR INEFFICIENCIES
ESTIMATE REQM'NT
(DSS)
GRAPHIC COMPARISON
PROGRAMMED INVENTORY BY MUNITION

Figure 4.1

5.0 APPLICATION OF THE METHODOLOGY

5.1 MUNITION SET

As mentioned earlier, the task included the examination of both air defense munitions and anti-tank munitions. While the methodology was applicable to either category of munition, the categories were sufficiently different to make it advantageous to develop two separate, albeit similar, decision support systems. Figure 5.1 shows a generic set of anti-tank munitions which will be used for discussion purposes. The spreadsheet requires that these munitions be listed in the first column and grouped by category as shown. Notice the next column in the spreadsheet has the title "Include". This allows the analyst to either include or not include a particular munition in the analysis. Therefore, from this generic set of munitions, numerous subsets can be constructed to represent different munition options. Also, note that the "other" category under the munitions is basically a "catch all" category for all those munitions which are on the battlefield and can kill the targets of interest but which do not need to be addressed explicitly in the analysis.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

INPUT THREAT QUANTITIES

MUNITION	INCLUDE (Y/N)	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE						
105 MM #1	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
105 MM #2	N	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
120 MM #1	N	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
120 MM #2	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
MANPAT #1	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
MANPAT #2	N	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
ATGM #1	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
ATGM #2	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
OTHER	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
INDIRECT FIRE BATTLE						
PGM #1	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
PGM #2	N	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
PGM #3	N	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
		xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
OTHER	Y	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx

AIR FORCE/ALLIES

Figure 5.1

5.2 THREAT QUANTITIES

The next portion of the spreadsheet allows the user to specify quantities for various threat targets as depicted in Figure 5.2. Note that the quantities are specified only for total categories of munitions, e.g., direct fire, indirect fire, etc.. Additionally, the quantities entered represent the total number which could be presented as targets to each category of munition. Thus, in the example, the threat is a total of only 1000 tanks (not 3000). All 1000 tanks could all be killed by any of the categories of munitions listed. How many of the 1000 tanks need to be killed and by which category of munition is the subject of the next few sections of the spreadsheet.

At this point, an editorial note is needed to help the reader understand how the DSS is organized on the electronic spreadsheet. Each of the figures referred to in the following paragraphs represents a single screen on the computer. Successive screeens are positioned from left to right across the spreadsheet by depressing the "tab" key.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

INPUT THREAT QUANTITIES

MUNITION	INCLUDE (Y/N)	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE		1000	80	20	50	0
105 MM #1	Y	********	********	********	********	********
105 MM #2	N	********	********	********	********	********
		********	********	********	********	********
120 MM #1	N	********	********	********	********	********
120 MM #2	Y	********	********	********	********	********
		********	********	********	********	********
MANPAT #1	Y	********	********	********	********	********
MANPAT #2	N	********	********	********	********	********
		********	********	********	********	********
ATGM #1	Y	********	********	********	********	********
ATGM #2	Y	********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
OTHER	Y	********	********	********	********	********
INDIRECT FIRE BATTLE		1000	80	20	50	0
PGM #1	Y	********	********	********	********	********
PGM #2	N	********	********	********	********	********
PGM #3	N	********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
		********	********	********	********	********
OTHER	Y	********	********	********	********	********
AIR FORCE/ALLIES		1000	80	20	50	0

Figure 5.2

5.3 REQUIRED KILLS

The threat quantities in Figure 5.2 represent the total threat. To accomplish the commander's objective, it is probably necessary to kill only a certain proportion of this total threat. What proportion actually needs to be killed is situationally dependent and, hence, very subjective. The DSS allows the decisionmaker, or his subject matter expert, to assign this proportion to each type of target. The proportion is entered just below the name of the target type, see Figure 5.3. Given the total threat quantity and the proportion that needs to be killed, the DSS calculates the required number of kills for each target type and munition category. Note that munitions designated as "N" in the "INCLUDE" category of Figure 5.2 are no longer displayed, see Figure 5.3. The spreadsheet automatically erases these rows because they are not needed.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

CALCULATE REQUIRED KILLS
(ENTER ATTACK CRITERIA IN ROW 10)

MUNITION	TANK 60%	BMP 40%	BRDM 40%	OTHER1 20%	OTHER2 0%
DIRECT FIRE BATTLE	600	32	8	10	0
105 MM #1					
120 MM #2					
MANPAT #1					
ATGM #1					
ATGM #2					
OTHER					
INDIRECT FIRE BATTLE	600	32	8	10	0
PGM #1					
OTHER					
AIR FORCE/ALLIES	600	32	8	10	0

Figure 5.3

5.4 ALLOCATION OF REQUIRED KILLS

Next, it is necessary to allocate the required kills to each munition by type. This is a two step process. First, the required kills are allocated to munition categories and then sub-allocated within each category to specific munition types. Figure 5.4.1 shows the allocation process to munition categories. Here the decisionmaker, or his subject matter expert, simply enters the proportion of each target type he expects to be killed by each category of munition. The proportions in each column must sum to 100%.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

ALLOCATE REQUIRED KILLS TO AO
(ENTER FACTORS IN ROWS 15 AND 34)

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE	70%	50%	50%	30%	0%
105 MM #1					
120 MM #2					
MANPAT #1					
ATGM #1					
ATGM #2					
OTHER					
INDIRECT FIRE BATTLE	20%	30%	30%	40%	0%
PGM #1					
OTHER					
AIR FORCE/ALLIES	10%	20%	20%	30%	0%

Figure 5.4.1

Having accomplished this, the DSS requires that the decisionmaker sub-allocate the proportion of each target type he expects to be killed by each munition type within each category of munition (Figure 5.4.2). The proportions within each munition category in each column must sum to 100%.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

ALLOCATE REQUIRED KILLS TO MUNITIONS
(ENTER ALLOCATION FACTORS IN TABLE BELOW)

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE					
105 MM *1	30%	35%	35%	5%	5%
120 MM *2	40%	35%	35%	5%	5%
MANPAT *1	5%	5%	5%	50%	50%
ATGM *1	10%	10%	10%	10%	10%
ATGM *2	10%	10%	10%	25%	25%
OTHER	5%	5%	5%	5%	5%
INDIRECT FIRE BATTLE					
PGM *1	90%	80%	80%	70%	70%
OTHER	10%	20%	20%	30%	30%
AIR FORCE/ALLIES	100%	100%	100%	100%	100%

Figure 5.4.2

With this input, the DSS calculates the required kills by munition type and presents these quantities as depicted in Figure 5.4.3.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

CALCULATE REQUIRED KILLS BY
MUNITION TYPE

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE					
105 MM *1	126	6	1	0	0
120 MM *2	168	6	1	0	0
MANPAT *1	21	1	0	2	0
ATGM *1	42	2	0	0	0
ATGM *2	42	2	0	1	0
OTHER	21	1	0	0	0
INDIRECT FIRE BATTLE					
PGM *1	378	13	3	2	0
OTHER	42	3	1	1	0
AIR FORCE/ALLIES	420	16	4	3	0

Figure 5.4.3

5.5 ROUNDS REQUIRED PER KILL

Having estimated the number of targets of each type which need to be killed by munitions of each type, the next step is to estimate the number of rounds of each munition type which must be fired to achieve a specified cumulative probability of a kill against a single target of a specified type. To calculate this estimate, the event of a single munition attacking a single target is modeled by a Bernoulli Process with success defined as a target kill. The probability of success is equal to the probability of single shot kill (PSSK). If it is assumed that the PSSK remains constant from shot to shot and that each shot is independent, then it is reasonable to represent the probability of success on more than one shot by the binomial distribution. Of particular interest is the number of shots needed to produce a successful outcome. The cumulative probability of of not killing a target in some number of shots, say "n", is equal to $(1-PSSK)^n$. Therefore, the cumulative probability of achieving at least one kill in "n" shots is given by $1 - (1 - PSSK)^n$. If a value for this cumulative probability is specified, say "k", then the equation of interest becomes:

$$k = 1 - (1 - PSSK)^n$$

This equation can be solved for "n" in the following manner:

$$(1 - PSSK)^n = (1 - k)$$

$$n * \ln(1 - PSSK) = \ln(1 - k)$$

$$n = \ln(1 - k) / \ln(1 - PSSK)$$

The decisionmaker, or his subject matter expert, enters the desired cumulative probability of kill in the parentheses labeled "SURETY FACTOR". When he does this, he is stating how sure he wants to be that he has enough rounds available to achieve a successful outcome. The DSS calculates the number of rounds required to produce this level of surety for each combination of munition type and target type as depicted in Figure 5.5.1

YEAR: 1986
MUNITION CATEGORY ANTI-TANK

CALCULATE ROUNDS REQUIRED PER KILL BY MUNITION
(ENTER SURETY FACTOR: 0.8)

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE					
105 MM #1	9.9	7.2	7.2	5.6	4.5
120 MM #2	7.2	5.6	5.6	4.5	3.7
MANPAT #1	15.3	9.9	9.9	7.2	5.6
ATGM #1	9.9	7.2	7.2	5.6	4.5
ATGM #2	5.6	4.5	4.5	3.7	3.2
INDIRECT FIRE BATTLE					
PGM #1	31.4	15.3	15.3	9.9	7.2

Figure 5.5.1

PSSK is frequently estimated in the analytical community and should be obtained from approved data sources. PSSK values must be entered for each combination of target and munition type as depicted in Figure 5.5.2. It is noted that this spreadsheet screen is out of sequence; it is the very last screen (right most) in the spreadsheet.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

PSSK TABLE

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2
DIRECT FIRE BATTLE					
105 MM #1	0.15	0.20	0.20	0.25	0.30
105 MM #2	0.15	0.20	0.20	0.25	0.30
120 MM #1	0.25	0.30	0.30	0.35	0.40
120 MM #2	0.20	0.25	0.25	0.30	0.35
MANPAT #1	0.10	0.15	0.15	0.20	0.25
MANPAT #2	0.30	0.35	0.35	0.40	0.45
ATGM #1	0.15	0.20	0.20	0.25	0.30
ATGM #2	0.25	0.30	0.30	0.35	0.40
INDIRECT FIRE BATTLE					
PGM #1	0.05	0.10	0.10	0.15	0.20
PGM #2	0.20	0.25	0.25	0.30	0.35
PGM #3	0.20	0.25	0.25	0.30	0.35

Figure 5.5.2

5.6 MAXIMUM EFFICIENCY ESTIMATOR

At this point, the DSS knows the number of each target type which needs to be killed by each munition type, and it knows the number of rounds required of each type of munition to achieve a single kill to some specified level of certainty. Hence, it is simple calculation to estimate the total number of rounds required by munition type. This is shown in Figure 5.6. However, the estimate assumes that all required munitions are at the right place, at the right time and are fired at separate targets. Obviously, this is not the case in battle. Therefore, the DSS requires an additional mechanism for considering the inefficiencies inherent in war.

YEAR: 1986
MUNITION CATEGORY ANTI-TANK

CALCULATE MAXIMUM EFFICIENCY ESTIMATE
FOR MUNITIONS REQUIREMENTS

MUNITION	TANK	BMP	BRDM	OTHER1	OTHER2	TOTAL
DIRECT FIRE BATTLE**						
105 MM #1	1248	40	10	1	0	1299
120 MM #2	1212	31	8	1	0	1252
MANPAT #1	321	8	2	11	0	342
ATGM #1	416	12	3	2	0	432
ATGM #2	235	7	2	3	0	247
INDIRECT FIRE BATT**						
PGM #1	11861	196	49	21	0	12126

Figure 5.6

5.7 INEFFICIENCY FACTORS

In order to compensate for real world wartime inefficiencies, the following five battlefield factors known to influence munitions requirements were selected:

a. Combat Losses are munitions which are destroyed before they can be used (e.g., while in ammunition supply points, while enroute to the forward areas, etc.). Also, included in the category are munitions on board damaged weapon systems which cannot be recovered.

b. Contingency Supplies are munitions pre-positioned outside the normal area of operations to support contingency missions.

c. Tactics are that portion of available munitions on board weapon systems which are not in the right place at the right time (i.e., they don't get into the fight.).

d. Sustainment Operations are that set of munitions which must be kept in reserve to fight the next battle.

e. Other are any additional factors which will influence munitions requirements.

For each munition/battlefield category, an estimate of the contribution of that factor is entered as depicted in Figure 5.7.1

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

INPUT INEFFICIENCY FACTORS

MUNITION	COMBAT LOSSES	CONTINGENCY SUPPLY	TACTICS	SUSTAIN OPNS	OTHER
DIRECT FIRE BATTLE**					
105 MM #1	10%	30%	5%	75%	0%
120 MM #2	10%	30%	5%	75%	0%
MANPAT #1	5%	30%	5%	75%	0%
ATGM #1	15%	30%	5%	75%	0%
ATGM #2	15%	30%	5%	75%	0%
INDIRECT FIRE BATT**					
PGM #1	2%	30%	5%	75%	0%

Figure 5.7.1

From the optimum munitions required for each target as depicted in Figure 5.6 and the efficiency factors entered for each munition as depicted in Figure 5.7.1, a final maximum efficiency estimate for each munition is then calculated as depicted in Figure 5.7.2.

YEAR: 1986
MUNITION CATEGORY: ANTI-TANK

FINAL ESTIMATE

	QUANTITY
DIRECT FIRE BATTLE	
105 MM #1	2858
120 MM #2	2753
MANPAT #1	734
ATGM #1	972
ATGM #2	555
INDIRECT FIRE BATTLE	
PGM #1	25707

Figure 5.7.2

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